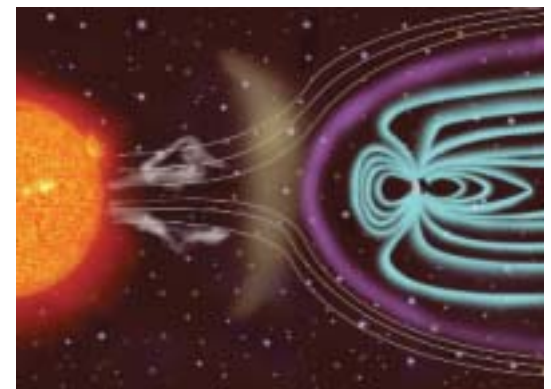
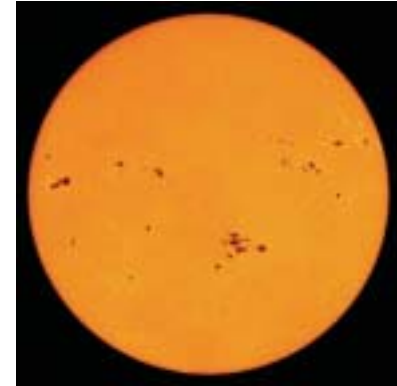
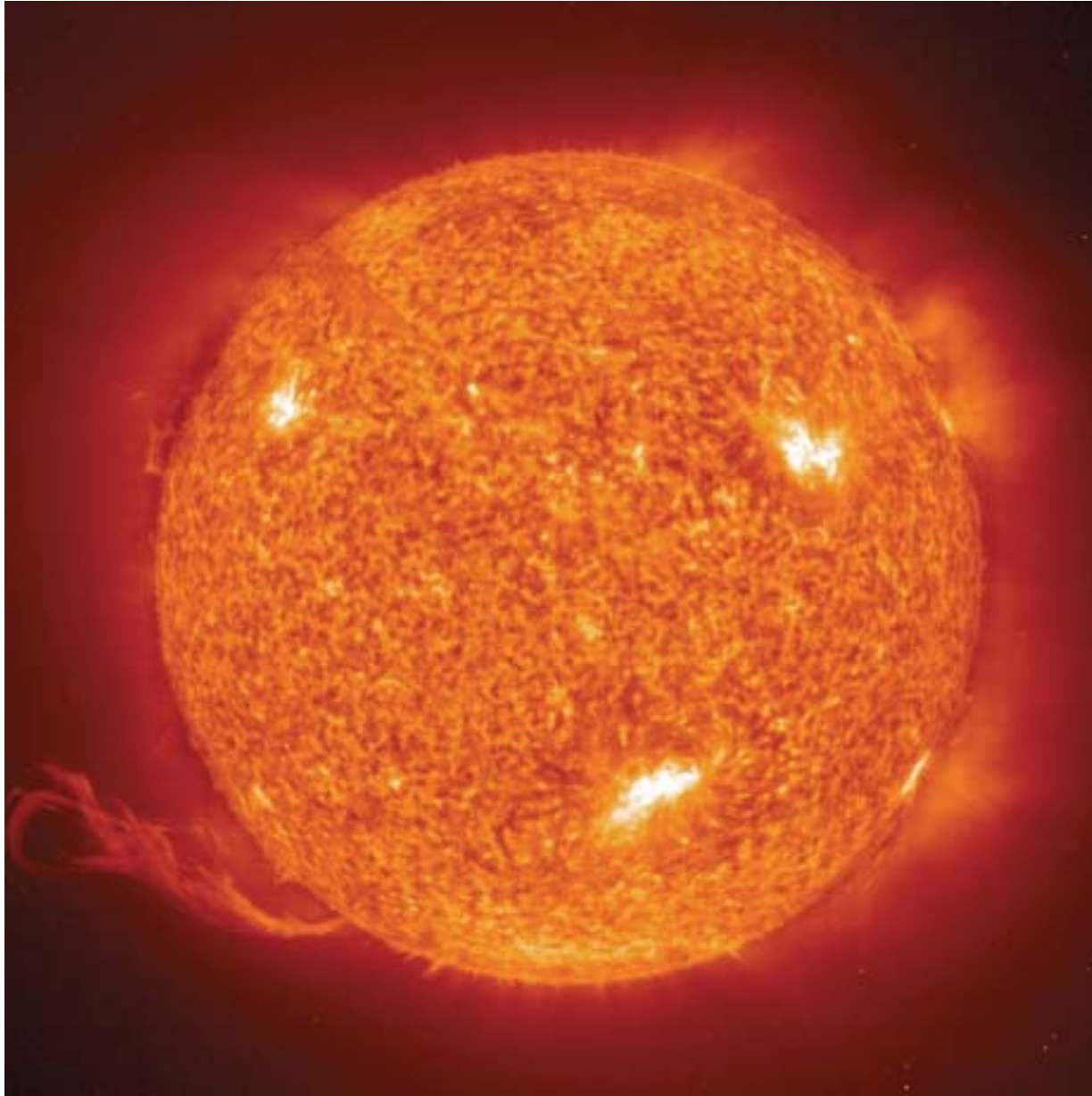




National Aeronautics and
Space Administration

Sun ☉





Our **SUN** has inspired mythology in almost all cultures, including ancient Egyptians, Aztecs, Native Americans, and Chinese. We now know that the Sun is a huge, bright sphere of mostly ionized gas, about 4.5 billion years old, and is the closest star to Earth at a distance of about 150 million km. The next closest star—Proxima Centauri—is nearly 268,000 times farther away. There are millions of similar stars in the Milky Way Galaxy (and billions of galaxies in the universe). Our Sun supports life on Earth. It powers photosynthesis in green plants and is ultimately the source of all food and fossil fuel. The connection and interaction between the Sun and the Earth drive the seasons, currents in the ocean, weather, and climate.

The Sun is some 333,400 times more massive than Earth and contains 99.86 percent of the mass of the entire solar system. It is held together by gravitational attraction, producing immense pressure and temperature at its core (more than a billion times that of the atmosphere on Earth, with a density about 160 times that of water).

At the core, the temperature is 16 million degrees kelvin (K), which is sufficient to sustain thermonuclear fusion reactions. The released energy prevents the collapse of the Sun and keeps it in gaseous form. The total energy radiated is 383 billion trillion kilowatts, which is equivalent to the energy generated by 100 billion tons of TNT exploding each second.

In addition to the energy-producing solar core, the interior has two distinct regions: a radiative zone and a convective zone. From the edge of the core outward, first through the radiative zone and then through the convective zone, the temperature decreases from 8 million to 7,000 K. It takes a few hundred thousand years for photons to escape from the dense core and reach the surface.

The Sun's "surface," known as the photosphere, is just the visible 500-km-thick layer from which most of the Sun's radiation and light finally escape, and it is the place where sunspots are found. Above the photosphere lies the chromosphere ("sphere of color") that may be seen briefly during total solar eclipses as a reddish rim, caused by hot hydrogen atoms, around the Sun. Temperature steadily increases with altitude up to 50,000 K, while density drops to 100,000 times less than in the photosphere. Above the chromosphere

lies the corona ("crown"), extending outward from the Sun in the form of the "solar wind" to the edge of the solar system. The corona is extremely hot—millions of degrees kelvin. Since it is physically impossible to transfer thermal energy from the cooler surface of the Sun to the much hotter corona, the source of coronal heating has been a scientific mystery for more than 60 years. Scientists believe that energy transfer has to be in the form of waves or magnetic energy. Likely solutions have emerged from recent *SOHO* and *TRACE* satellite observations, which found evidence for the upward transfer of magnetic energy from the Sun's surface toward the corona above. Researchers in NASA's Sun-Earth Connection Space Science theme study these mysterious phenomena.

Fast Facts

Spectral Type of Star	G2 V
Age	4.5 billion years
Mean Distance to Earth	150 million km
Rotation Period (at equator)	26.8 days
Rotation Period (at poles)	36 days
Diameter	1.4 million km
Mass	1.99×10^{30} kilograms
Composition (number of atoms)	92.1% Hydrogen, 7.8% Helium
Temperature (photosphere)	5,780 K
Energy Output (luminosity)	3.83×10^{33} ergs/sec

Significant Dates

585 BC	First solar eclipse successfully predicted.
1610	Galileo observes sunspots with his telescope.
1650–1715	Maunder Sunspot Minimum discovered.
1854	First connection made between solar activity and geomagnetic activity.
1868	Helium lines first observed in solar spectrum.
1942	First radio emission from Sun observed.
1946	Corona temperature discovered to be 1,000,000 K.
1959	First direct observations of solar wind made by <i>Mariner 2</i> .
1973–74	<i>Skylab</i> observed Sun, discovered coronal holes.

1982	First observations of neutrons from a solar flare by <i>Solar Maximum Mission (SMM)</i> .
1991	Japan's <i>Yohkoh</i> satellite studies x rays and gamma rays.
1994–95 & 2000–01	ESA/NASA <i>Ulysses</i> mission studies polar regions of Sun.
1995	ESA/NASA's <i>Solar and Heliospheric Observatory (SOHO)</i> studies the solar interior, atmosphere, and wind.
1998	NASA's <i>Transition Region and Coronal Explorer</i> satellite observes the photosphere, transition region, and corona.

About the Images

(Left) Activity in the Sun seen in extreme ultraviolet by the *SOHO* satellite. Large erupting prominences (such as seen in the lower left of the image), when aimed in the direction of the Earth, can cause major disruptions in the near-Earth environment, affecting communications, navigation systems, and even power grids. The effects of these solar storms can be seen as auroral displays near the Earth's poles, the Northern and Southern Lights (*SOHO/ETI*).

(Right, top) The surface of the Sun with several sunspots. A sunspot is a dark part of the Sun's surface that is cooler than the surrounding area. A sunspot also temporarily has a concentrated magnetic field. This magnetic force inhibits the convective motion that ordinarily brings hot matter up from the interior of the sun. Sunspots are about 4,000 K, compared to the temperature of 5,700 K in the rest of the photosphere (*SOHO/MDI*).

(Right, center) Clusters of majestic hot coronal loops span 30 or more times the diameter of planet Earth (*TRACE/MSAD*).

(Right, bottom) Artist's conception of high-speed gas from the Sun, the solar wind, traveling at speeds ranging from 250 to 1,000 km per second as it sweeps past and distorts a planet's magnetic field. NASA's *Genesis* mission will bring samples of the solar wind back to Earth (*SOHO/Extreme Ultraviolet Imaging Consortium*).

References

- 1) Sun-Earth Connection Education Forum: <http://sunearth.gsfc.nasa.gov>
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- 3) Yohkoh Public Outreach Project: <http://solar.physics.montana.edu/YPOP>
- 4) *Ulysses* Mission: <http://ulysses.jpl.nasa.gov>
- 5) *Solar and Heliospheric Observatory (SOHO)*: <http://sohowww.nascom.nasa.gov>
- 6) *Transition Region and Coronal Explorer (TRACE)*: <http://vestige.lmsal.com/TRACE>
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